

Record of the Decontamination and Decommissioning (D&D) Workshop Defining Research Needs

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Foreword

The Decontamination and Decommissioning (D&D) Workshop: Defining Research Needs was held August 8 and 9, 1996 at the Hotel Roanoke & Conference Center in Roanoke, Virginia. Ninety-six persons attended the workshop, which was sponsored by the Morgantown Energy Technology Center (METC), the lead organization for the D&D Focus Area. The workshop was co-sponsored by the U.S. Department of Energy (DOE), Office of Environmental Management (EM), Office of Science and Technology (OST).

The purpose of the workshop was to bring together representatives from industry, universities, and DOE to discuss the decontamination and decommissioning needs of DOE and industry and to determine what research capabilities and expertise universities have to meet identified needs.

The workshop included presentations on METC, the EM program, and OST's D&D program. An industry panel representing commercial nuclear utilities, service organizations for commercial nuclear utilities, and technology development organizations talked about general industrial needs for D&D research. A proposal to establish a D&D center of excellence was explained. The first day concluded with breakout sessions where industry and university representatives explored opportunities for universities to conduct research to meet industries' and DOE's D&D needs. The participants in the breakout sessions discussed D&D needs in the areas of: characterization, decontamination, dismantlement, waste disposal and recycling, and systems integration. On the second day, group leaders from each breakout session presented the groups' findings to the workshop as a whole.

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1 Introduction

Paul Wieber, Associate Director for Institutional Development at Morgantown Energy Technology Center (METC), presented an overview of the workshop agenda and spoke about METC's mission and activities.

The Morgantown Energy Technology Center is located in Morgantown, West Virginia, south of Pittsburgh. METC is a federally-owned and federally-operated facility providing technology management services in energy and environmental technologies. METC has been delegated federal procurement authority. It maintains a legal staff and environmental health and safety support. It employs 300 federal employees and 350 contractor support personnel. Its budget for fiscal year 1995 was over \$600 million.

METC's four primary business sectors are 1) advanced power systems, 2) environmental waste management, 3) technology management services, and 4) fuels resources supply and processing. METC's technology management services support the other three business sectors.

Through partnerships with the private sector, METC conducts applied and engineering-scale research and development for advanced energy and environmental technologies, demonstrates and verifies performance of technologies, and conducts systems analysis to assess technologies' cost and performance.

METC's strategy for technology development can be described as market-driven and product-oriented. METC helps the private sector become involved in marketing its products within and outside the DOE market. This strategy will pay off in more jobs and increased U.S. competitiveness.

In partnership with DOE's Office of Science and Technology (OST), METC develops and manages technology development projects with private-sector participants. METC is the lead organization for OST's Decontamination and Decommissioning (D&D) Focus Area. METC also supports other focus and crosscutting areas.

METC performs as a virtual organization for DOE's Office of Environmental Management (EM). By developing partnerships with other organizations, METC provides valuable services to EM. For example, METC's management of Industry Programs brings the expertise of 72 private-sector contractors into the technology development program. METC's relationships with national laboratories, West Virginia University, the University of North Dakota's Energy and Environmental Research Center, and the International Union of Operating Engineers National HAZMAT Center helps provide technology development assistance to the EM program.

2 Welcome

Leonard Peters, Vice Provost for Research and Dean of the Graduate School at Virginia Polytechnic Institute and State University (VPI), welcomed the workshop participants on behalf of the university. Dr. Peters described the levels of integration that are necessary to achieve partnerships among government, industries, and universities. The first level is achieving an integration among government, industrial, and university cultures. The second level is integrating disciplines within the university world to achieve a multidisciplinary approach to researching D&D needs. The question is, “What academic disciplines are involved in D&D?” The third level of integration involves linking several projects to accomplish the overall goal.

VPI is a land-grant institution with 24,000 students, 6,000 of whom are graduate students. The predominant disciplines are the physical and engineering sciences. VPI has had numerous successes in developing partnerships. The Center on High Performance Polymeric Adhesives and Composites, or the “glue center,” is one example. Research at the glue center is funded by the National Science Foundation and by aircraft industries.

Another successful partnership exists between the university and the Waste Policy Institute (WPI), an university-affiliated, non-profit organization. Through its association with VPI, WPI enjoys benefits such as access to university resources. By working with WPI on projects, Virginia Tech can respond more quickly to opportunities.

3 EM Program Description

Stephen Lien, Chief Scientist and Senior Technical Advisor for OST, provided a quick walk through the Environmental Management organization, so workshop participants unfamiliar with the program could get a feel for the root causes of problems.

The major components of the Office of Environmental Management are the Offices of Waste Management (EM-30), Environmental Restoration (EM-40), Science and Technology (EM-50), and Nuclear Material and Facility Stabilization (EM-60). These offices are working to rectify the major environmental problems caused by 50 years of nuclear weapons production. The DOE’s mission to develop and produce nuclear weapons began 50 years ago with the Manhattan Project. Today, approximately 100 sites in 34 states and territories exhibit different problems associated with the U.S.’s nuclear legacy. These sites have diverse geographical and geological features that will require diverse solutions.

Nuclear weapons production involved mining and milling uranium, refining and enriching uranium, metal working, fabrication and assembly of plutonium weapons, plutonium reactor operations, and reprocessing of spent fuel.

During his whirlwind tour of DOE sites, Dr. Lien pointed out needs for better remediation solutions to meet site problems.

- Hanford Site in Richland, Washington was the world’s first spent-fuel reprocessing facility. B plant at Hanford is known as the “Queen Mary.” Single-shell tanks at Hanford each hold one million gallons of high-level liquid waste. Tank 104-U at Hanford is a known leaker.

- Idaho National Engineering Laboratory (INEL) is a huge underground storage site for mixed waste. Technologies to decontaminate and decommission the old calcine processing facility at INEL are yet to be developed.
- Sandia National Laboratories is the home of many hazardous landfills.
- Nevada Test Site is dusty and requires an effective way to suppress dust during remediation.
- Oak Ridge National Laboratory (ORNL) is the home of the K-25 plant, a gaseous diffusion facility. Can an economical way be found to recover and recycle nickel, a by-product of the gaseous diffusion process?
- Pantex Site in Texas was where nuclear weapon systems were assembled.
- The Defense Waste Processing Facility at the Savannah River Site in Aiken, South Carolina is an Environmental Restoration site that is currently operating to vitrify high-level waste.

DOE has charged EM to remediate the environmental legacy stemming from nuclear weapons production. OST within EM is carrying out an aggressive, national program of applied research, development, demonstration, testing, and evaluation, augmented by targeted, long-term basic research. Within OST, focus areas are organized to address the major problems of mixed waste, subsurface contaminants, high-level waste tanks, and decontamination and decommissioning. The lead organizations for each of the focus areas are: mixed waste – Idaho Operations Office; subsurface contaminants – Savannah River Operations Office; high-level waste tanks – Richland Operations Office; decontamination and decommissioning – METC. OST's budget for fiscal year 1996 is \$350 million plus \$50 million for basic research.

4 Current D&D Program

Paul Hart, Product Manager for the D&D Focus Area at METC, presented an overview of DOE's D&D program. Dr. Hart described the problem in terms of 7,000 buildings contaminated with a combination of radioactive and hazardous materials. Slightly less than 1,000 of the 7,000 buildings are currently undergoing decommissioning. The rest of the approximately 6,000 buildings have been characterized. The D&D process moves a facility along a continuum from deactivation involving characterization; decontamination to remove radioactive and hazardous components; dismantlement to break up equipment and structures into small pieces; disposition of decontaminated pieces as waste or recycled materials; and finally decommissioning. It is estimated that it will take 70 years and cost \$56 billion to completely decommission all 7,000 buildings using the current baseline technologies. The mission of the D&D Focus Area is to develop technologies that can accomplish this task quicker and cheaper.

The D&D Focus Area represents partnerships among DOE users in the Site Technology Coordination Groups; U.S. Army Corps of Engineers; METC's Industrial Programs; D&D Focus Area independent review panels; and the crosscutting areas of the Robotic Technology Development Program; the Characterization, Monitoring, and Sensor Technology Crosscutting Program; and Efficient Separations and Processing.

The problems faced by the D&D Focus Area are comparable to those faced by commercial nuclear facilities. The focus area uses product lines to categorize the types of facilities to be

decommissioned: processing facilities, reactor facilities, laboratory facilities, and infrastructure and support activities.

The focus area is using large-scale demonstrations to integrate facility decommissioning projects with demonstrations of a suite of improved technologies. Three decommissioning projects have been chosen to meet the needs of users within EM-30, EM-40, and EM-60. The three large-scale projects the focus area is currently planning and executing are: Chicago Pile-5 Reactor decommissioning at Argonne National Laboratory, Fernald Plant-1 decommissioning in Ohio, and interim safe storage of 105-C Reactor at the Hanford Site in Richland, Washington. The projects will incorporate advanced technologies for decontamination of scrap metal, characterization of radiation inside pipes with the Pipe Explorer system, the Advanced Worker Protection System, automated asbestos removal from pipes, and others.

5 Output from 1995 Workshop

Steven Bossart, Project Manager at METC, presented the results of a D&D needs workshop held at METC in July 1995, "A New Focus for Technology Development, Opportunities for Industry/Government Collaboration." The purpose of the meeting was to capture industries' experiences and lessons learned and incorporate this information into DOE's D&D program. Panels discussed: 1) industry approaches to D&D and 2) barriers to industry/government collaboration.

Following are the key points that arose during the panel discussion on industry approaches to D&D:

- One-third of decommissioning cost is waste disposal.
- DOE should focus on the integration of technologies into effective and efficient systems, not just on the technologies as separate products.
- Over application of OSHA rules and onerous documentation and review requirements lead to significant DOE D&D costs.
- Cost sharing arrangements between DOE and technology developers that lead to successful demonstrations should guarantee technology developers receive contracts for any remediation work involving that technology.
- Performance data for baseline technologies is needed as a basis of comparison with innovative technologies.
- Three factors influence technology acceptance: market opportunity, life-cycle costs, and stakeholder and regulatory acceptance.
- D&D costs can be reduced by reducing waste volume, streamlining regulations, and developing real-time characterization systems.

Following are the key points that arose during the panel discussion on barriers to industry/government collaboration:

- Cooperative Research and Development Agreements (CRADAs) do not work well for small companies, because small companies do not have the funds to put into R&D.
- Penetrating the DOE procurement system is a barrier, because DOE does not offer clear direction.

- DOE institutes inefficient rules for companies working at DOE sites. For example, DOE training rules do not recognize training workers have acquired from Nuclear Regulatory Commission (NRC) or American National Standards Institute.
- DOE must guarantee private-sector intellectual property rights.
- Opportunities for private-sector collaboration are limited when national laboratories maintain all work in-house.
- Foreign technologies should be considered for inclusion in DOE's D&D program.
- Fixed price contracts for technology development create barriers, because they are too risky for the private-sector.

6 Results of July 1996 Site Technology Coordination Group Meeting

Paul Hart presented the process and results of site surveys to determine D&D needs at DOE sites. The purpose of the needs assessment is to direct the development of a technology investment strategy whereby limited DOE resources are funneled to solve priority needs.

The Site Technology Coordination Groups (STCGs) are composed of scientists, engineers, and other personnel at DOE sites who are responsible for remediating site environmental problems. During the first six months of 1996, D&D Focus Area representatives conducted DOE site visits to describe the D&D Focus Area program and solicit individual site D&D problems from STCGs. From field perspectives, the focus area identified 102 needs for technology development to address D&D problems.

The 102 problems were grouped into 31 problem areas and prioritized during a National D&D Workshop held on July 24 and 25, 1996 at METC. Priority was based on a cumulative, weighted scoring system that considered the impact of the problem on eight evaluation criteria: the safety and health of the public; site personnel safety and health; environmental protection; compliance with applicable laws and regulations; accomplishment of DOE's mission; mortgage reduction; social, cultural, economic concerns; and pervasiveness of need.

The needs assessment will help the D&D Focus Area match technical activities against needs. By the end of September, the D&D Focus Area hopes to have a first cut on the integration of needs with technology development activities.

7 Industry Needs Panel

Before hearing presentations from an industry panel on their D&D needs, Paul Wieber said he wished to share with the workshop a question he had been asked during the break. The question was, "How will the D&D Focus Area, which is scheduled to sunset by the year 2000 or so, be able to work with universities with their long-range views?" Wieber answered that part of the D&D program involves cocooning sites and parts of sites where technologies don't currently exist to completely or cost effectively decommission them. So there is a long-range component of this problem that may outlive the focus area, or may

even extend the focus area depending on the situation. Certainly, D&D needs will extend into the future beyond present organizational structures.

Robert Bedick, Manager of the Environmental Business Sector of METC, introduced the members of the industry panel, who represented commercial nuclear utilities, service organizations for commercial nuclear utilities, and technology development organizations. In short presentations, the panel members answered the question, “If the government plans to support research and development in the university community in the area of D&D, how should the funds be spent to benefit your industry?” The intent of the industry panel presentations was to stimulate discussion before participants went into the breakout sessions.

Bruce Holmgren

Engineering Manager

Yankee Atomic Electric Company

Bolton, Massachusetts

Yankee-Rowe is a 185-megawatt commercial nuclear plant located in western Massachusetts. It operated from 1961 to 1992. It was a Westinghouse four-loop PWR. We’ve been performing decommissioning work since 1993. All four steam generators, pressurizer, reactor internals, all with much of the piping and other equipment, have already been removed. At the present time, we’re still performing minor decommissioning activities and will continue to do so until our decommissioning plan is reapproved by the NRC. Right now, we have 533 spent fuel assemblies stored in our spent fuel pool, awaiting departure to a DOE storage facility. Plant systems required to support spent fuel storage and to support permanently defueled operations are still in service.

The Yankee Plant is a small plant, but it’s a conventional nuclear plant. Most of the structures are reinforced concrete and steel. The next major phase of decommissioning is the final status survey, leading to release of the site for unrestricted use; unless the site is used for low-level waste storage as has been suggested. We intend to do this final status survey on the available plant structures with spent fuel still in the pool. After the final site survey, we’ll use standard demolition equipment to dismantle all the structures.

Research Needs:

A robotics system to perform wall and floor surveys. Automation of radiological surveys would reduce the need for scaffolding, require fewer people, and result in lower total dose to the survey crew. Our final status survey plan calls for multiple passes of instrumentation. If we had an automated system, which could store all of this information, it would reduce cost, lower dose, and result in reproducible, documentable results. In conjunction with this, an in-situ gamma spectrometer reader, a device that is both a micro r meter and a count rate meter would eliminate the two-step process.

A pipe crawler, which inspects, decons, and surveys. This system would move through a large- or small-bore pipe on its own power, inspecting the surface condition of the pipe, cleaning it, and performing a confirmatory survey of the pipe. This would be of particular benefit for buried pipe and pipe that’s encapsulated in concrete. I know such devices now exist, but there is little competition.

A study of the effect of impact hammer devices on concrete that must remain in service. There are several vendors with electrohydraulic-driven demolition robots, which can be outfitted with hammers or scabblers, and we plan to use such a device. That equipment has proven itself in many applications. Our problem is that we plan to use these devices next to our spent fuel pool, with fuel still in the pool. Although the resulting vibrations will undoubtedly be of low energy, we've been unable to find any data that benchmarks the effects of such equipment on concrete that must remain functional.

Equipment to decon concrete and steel that does not require operating personnel to be in respirators and without building containment around the area. For example, we intend to use a demolition robot with a scabbler on the ends of an articulating arm to remove concrete to a depth of three-quarters of an inch or more. Anything we could do to lighten that weight and extend the arm would be an improvement.

Decon equipment that is fast, light-weight, minimizes airborne radioactivity, minimizes generation of secondary waste, and requires essentially no water.

A floor cleaner that removes more than a quarter inch of concrete, leaves a smoothly finished surface, gets close to corners, and operates at better than two square feet per minute. When we do our final survey, we will be able to do it quickly and accurately.

A temporary liquid waste treatment system, preferably a reverse osmosis unit, to handle boron, large swings in pH in the process water, processes at least 10 GPM, and generates a minimum of solid waste products. We're now installing a temporary liquid waste system using evaporative technology, so we can dismantle our original evaporator unit.

Jim Byrne

Manager, Decontamination and Decommissioning
GPU Nuclear, Inc.

I spent 13 years putting Three Mile Island Unit-2 into monitored storage, and we're still doing some dismantlement work there. We'll move the radiological portions in the next couple of years. GPU also owns a small research reactor in Central Pennsylvania, a 23.5-megawatt thermal reactor called Saxton. It's a 200,000-cubic foot containment vessel. Everything is packed neatly inside Saxton, and we're starting to dismantle as we speak.

Research Needs:

We're looking for technologies that are faster, cheaper, and easier.

Minimize effects on the worker in the field. Reduce workers' heat stress, and reduce the amount of anti-contamination clothing they have to wear.

On-site characterization. We just finished characterizing the Saxton facility. We had to send several pipe samples to an off-site laboratory to determine the alpha/beta contamination. If we could have done that in-situ, especially from outside pipes, that would have been useful to us.

Determine contamination in small-bore piping.

Reduce hazards due to lead-based paints. Saxton is an old facility and practically every surface is covered with lead-based paint. Protecting against the hazards of volatilization of lead-based paint, in terms of protective clothing, probably requires more of us than for radioactive contamination protection. So a way to stabilize lead-based paint would be useful.

Stephen Schutt

Executive Vice President, Business Development
Nuclear Field Services, Inc.

For the past 15 years, NFS has been the sole source supplier of nuclear fuel to the U.S. Navy for its aircraft carriers and Trident submarines. We've been in the nuclear business, though, for over 40 years. We built and operated West Valley. We no longer have any ties to West Valley, but some of the reprocessed plutonium went to our facility in Erwin, Tennessee, where we manufacture fuel.

We've produced and manufactured mixed oxide fuel assemblies — both plutonium and uranium. Therefore, we've had a plutonium mixed oxide fuel fabrication facility that's had to be decommissioned. We had waste lagoons back when the regulations were written differently. These lagoons were acceptable then, but now they aren't. They held sludges containing actinides (thorium, uranium, plutonium, and americum), as well as RCRA metals (cadmium and TCE). These truly mixed waste lagoons presented quite a D&D problem, because they were unlined and a spring of 300 gallons per minute ran between the lagoons from the mountains.

We also have numerous facilities we are currently decommissioning. We are constantly looking for better ways to perform these decommissioning efforts. We're also manufacturing fuel for the Navy. We have completely decommissioned our plutonium mixed oxide fuel fabrication facility, including our mixed waste lagoons. We have taken care of about 250 drums of mercury mixed waste, rendering it non-hazardous and acceptable for disposal at Envirocare. We still have problems to resolve. We've been at decommissioning now about 10 years and are spending anywhere from \$20 to \$30 million a year on our decommissioning efforts.

Research Needs:

Systems integration. You can put a fixative on a glovebox to keep the radioactive materials from escaping while you handle the glovebox. But what's the next unit operation? The next unit operation is to dismantle that glovebox and decontaminate it. If that fixative happens to be a solvent-based or metal-based fixative, you've just created a mixed waste problem. You've just made it much more difficult to decontaminate the glovebox. So I would like to see much more work going on in systems integration where you look at a facility or a unit problem, and instead of having pieces laying out everywhere that can handle one point of the problem, you've got to look at it from the point of view of the whole chain. Having a plasma arc to cut metal is great, unless you're cutting a glovebox with plutonium inside and you've just contaminated your whole area. You should be looking at both the upstream

and downstream unit operations, not just the unit operation you're designing. How well does this step fit into the next step and the previous step?

Rock Aker

Project Manager

Commonwealth Edison, Nuclear Strategic Services

COMED is the largest commercial nuclear utility in the United States. We own and operate 13 power reactors, 12 of which are currently operating and one, our Dresden Unit-1 facility, which is currently in safe stored decommissioning. All our facilities are located in the northern third of Illinois and generate 80 percent of our utility's nuclear power base. My organization has the responsibility of decommissioning our Unit-1 at Dresden, but eventually the other 12 reactors will require decommissioning as well. We have a long-term issue with D&D, as does the commercial nuclear industry, well beyond the year 1999, so there will certainly be needs for D&D technologies and improvements well into the next century.

We estimate that for us to decommission our 13 reactors with technologies available today, it will cost approximately \$15 billion in year of expenditure. So if you talk about the ballpark of 100 commercial nuclear reactors in the country, that's a substantive investment, in addition to the DOE complex costs for D&D into the next century. So it's definitely a non-trivial need to reduce things even incrementally.

As the commercial nuclear industry moves toward deregulation, it is going to become more critical for us as utility owners to do things faster, cheaper, and easier, because the companies' survival depends on that.

There are many similarities between the DOE complex needs for technology and the commercial nuclear industry's needs. In fact, of those 31 technology needs, I say 25 of them at least are commercial reactor needs as well. That's positive. That means there's more cost effective use of technology for the complex and commercial utilities.

Research Needs:

Waste reduction is probably a substantially bigger need for commercial utilities than it is for DOE. There are varying rates for waste disposal. Ballpark numbers for the commercial industry for low-level waste disposal is somewhere between \$300 and \$400 per cubic foot. If you can shave a few cubic feet off your waste, that's money, particularly when you're talking potentially thousands of cubic meters of waste to dispose.

Better survey techniques will help us accomplish waste reduction by providing knowledge of how much contaminated concrete, for example, has to be removed. Can you shave off three mils of concrete that's contaminated versus 25? If you can, that's a waste volume reduction that's money in the bank.

Improved on-site characterization of contamination within concrete. Can you do it other than with core bores? Can you quickly and remotely determine depth of contamination of both radionuclides and possibly other contaminants in concrete?

Reduce uncertainties in waste disposal for both low-level mixed waste (primarily lead and asbestos) and high-level waste and spent fuel.

Standardized criteria for free release. The commercial nuclear utility industry does not have a consistent endpoint for determining clean. Is it 15 millirem per year? Is it 5 or 100 millirem per year? The NRC continues to work on those regulations. But until we have a discernible endpoint, you may be spending insufficient funding or too much. So anything we can do jointly with academia and the complex to work toward rational risk-based endpoints is money in everyone's pocket.

Continued collaboration. As the commercial utility industry moves toward deregulation, communication between companies within the industry will be reduced due to competitive issues. That means there's going to be less transfer between the commercial utility companies. So I urge DOE and academia to keep those channels open.

Tritium reduction and avoidance. Most of our facilities have spent fuel pools, or process fluids that have tritium in them. If there is a cost effective means to extract tritium, that would be substantive waste and cost reductions for us. And frankly, we might be able to sell the tritium back to DOE.

Robotics. We need probably fewer large, robust systems but more mobile, multi-purpose platforms easily decontaminated and easily run by untrained robotics operators, not only in decommissioning, but also in operations and maintenance of ongoing plants.

George Brown

Executive Vice President and Group President of the Consulting Group
ICF Kaiser, International

Research Needs:

Cost control and cost management. The opportunity and role of technology is to bring down the cost of D&D operations. You can't win jobs unless you can effectively control costs. You can't also make any money on a job unless you can control and predict the cost of operations. So, when you think about the center of gravity for research efforts, controlling costs is the opportunity for payoff.

Four particular areas of focus:

Labor productivity. D&D is a labor-driven set of costs. During every state of D&D, the key tasks, characterization in particular, involve significant health and safety concerns. To save on labor costs and make labor more efficient, research should focus on:

- Robotics
- Advances in worker protection technologies
- Advanced characterization technologies that either make workers more efficient or enable substitution of robotic technologies for workers in the characterization process.

High volume/high mass materials. Concrete, shielding, and piping costs can be modest, but the volume of the needed materials makes the overall cost quite substantial. Small

percentage reductions that are multiplied by very large numbers end up having a very large impact.

Stakeholder/community/regulatory acceptance. A long history of confrontation and opposition needs to move toward a partnership and problem solving orientation. This topic relates to labor productivity, because much of the work force is involved in resolving these kinds of issues.

Knowledge dissemination. Most companies do a very small number of very large D&D projects. Technology transfer, benchmarking, and best practice documentation would make an enormous contribution to those working in the field. There is always competition among the players in the industry, but there is an opportunity for all boats to rise, or unfortunately all boats to sink, depending on the state of knowledge and the effectiveness of learning and disseminating best practices.

Jim Gutzwiller

Vice President, Chemistry and Environmental Services
Framatome Technologies, Inc.

We're the former B&W Nuclear Technologies. We primarily do service work in the commercial nuclear industry. We're owned wholly by Framatome, which is the world's largest supplier of PWR units and is located in France. We're a relatively new player in the area of government D&D. We don't pretend to know those needs, but we're learning. Framatome's core competencies are robotics, non-destructive examination, remote cutting and welding, high pressure water cleaning, and chemical cleanings and processes, including decontamination of waste.

Applied Research Needs:

Teaming universities with companies. We have done that with VPI in the area of robotics; and through that partnership we developed our latest robotic manipulator for steam generator work. Teaming melds the practical knowledge of how to do work with universities' research and advances in state-of-the-art. Teamwork of industries and universities will produce better products.

Joint testing facilities. Research could be carried out either at universities where decontamination projects could be conducted on campus, or at facilities where companies have licenses to handle nuclear materials. It's smarter to conduct laboratory testing before conducting a full-scale demonstration.

Avoiding secondary wastes. For example, if you use chelates to extract oxides during a decontamination of a pipe, you're left with mixed waste, organics, and some RCRA hazards.

Communicating with stakeholders. I concur with George on stakeholders being key. We need to communicate and make sure everyone knows what we are doing and what the risks are.

Basic Research Needs:

A basis for standardized free release.

The lead to gold scenario. We need to increase the rate of radioactive decay.

Dale Keairns

Manager, Chemical and Environmental Technologies
Westinghouse Science and Technology Center

Research Needs:

Our real challenge is how to identify technologies that can balance this tradeoff between cost, time, and risk. There are different kinds of research needs on a continuum from solutions to discrete problems to solutions involving integration of systems.

Real-time, on-site innovation requires very creative people to be available to do research in real-time.

Focused technology options is the next rung of the ladder. For example, improved techniques for real-time characterization.

Coupled technology problems is the next level. Steve and some of the others illustrated this set of problems. When dismantling a large structure, for example, the what and the how needs to be coupled with what you're going to do with resource recovery. One needs to be thinking of these technologies not in isolation, not as just a piece, but as the whole puzzle, the whole integrated system.

Interdisciplinary problems is the next dimension and the greatest challenge. In this realm, technology options are weighed against regulatory and administrative constraints, stakeholder issues, and public policy. Deactivation choices are weighed against D&D choices. Fitting this larger puzzle into a framework involves a systems approach. The cost savings as we go up the ladder of research needs are much more significant and can be realized if we can achieve some integration of technologies, risk, and regulatory and stakeholder standards. There are longer terms and higher risk in solving these problems, because they include multiple people and multiple, vested interests. I concur with the recommendations of the Council on Competitiveness report on D&D policy that to do these things we're going to need partnerships and they're going to have to be interdisciplinary. I think there is already guiding work that we can build on.

Creative ways to partner. I suggest we think about not just what research to do but how to creatively collaborate to implement university research. For example, a graduate student pursuing a practice-oriented masters degree could be on-site to see many of the interdisciplinary issues first-hand to provide an applied basis for his university research.

Hank McGuire

Vice President, DOE Programs
Foster Wheeler Environmental Corporation

I spent the last 20 years of my life working within the DOE complex, running waste management, D&D, and environmental restoration programs. Most of the needs on the list of 31 apply throughout the DOE complex.

DOE Research Needs:

New technologies. DOE has been cocooning and putting things in safe standby for the last five or six years. But they're getting ready to tackle some tough sites, such as chemical processing facilities and reactors. A whole new set of technologies are needed to do this cost effectively.

Characterization. Large centrifuges are loaded with tons of valuable nickel. If we can get inside and characterize, so we know what we need to clean up, we can save a lot of money. Hanford has 600 miles of highly radioactive pipe, most of which was simply shut down without being characterized. Some of these pipes are 20 to 25 years old. At the Redox plant, they had a drip of radioactive material. They tested it, assuming it was lab waste, and discovered it was highly transuranic. So, characterization of waste in difficult locations is an important need, especially remote characterization for inaccessible areas.

Decontamination of large buildings and large pieces of equipment. Collaboration between industry and government would allow industry to share in rewards for decontaminating and recycling nickel.

Decontamination techniques to minimize secondary waste. DOE users at sites are disappointed with commercially available liquid solvents. They would prefer not to use liquid and would prefer ablation, like blasting with CO₂ or other techniques that minimize secondary waste. Opportunity here is for methods that generate little waste. DOE managers are rewarded for waste volume reduction.

Spent fuel at Hanford. This may no longer be an opportunity area. With the acceleration of the contract at Hanford, that window of opportunity is closing or closed. I think that basin is set for cleanup by the year 2000. Unless you're there now with technologies ready to work, you're going to have trouble convincing DOE to consider new technologies.

Characterization for free release. There are probably 10 miles of pipe at Hanford right now that we believe is clean, but the mechanism for proving that is not available. So, the material can't be recycled.

The culture at DOE is changing. Rewards are for cost effective cleanup and risk mitigation, but not for technology development. Technologies will only be considered by the contractors if a) they are forced down their throat, which is not happening, or 2) they can show some schedule or cost containment. Hazel O'Leary made an announcement on Tuesday in which she talked about four different sites: Hanford, Savannah River, Mound, and Oak Ridge. The common themes were "low cost", "schedule acceleration", "assumption of risk", and "economic development within the community." So any technology that fits into the DOE complex, in terms of the contractors who are bidding or the people doing the work, has got to fit into a scheme that allows the successful, large companies within the DOE complex to perform in a cost effective manner.

Get an industrial sponsor if you can and get a stakeholder sponsor if you wish. Two examples of companies that have done well are Molten Metal and Rust Geotech. Molten Metal has a strong corporate sponsor in Lockheed Martin. Rust Geotech has a strong presence at Hanford in downwell logging, which was helped by the Heart of America, a large watchdog group at Hanford that has been a strong advocate of improved downwell monitoring techniques as advocated by Rust Geotech. So it really helps to not only get along with corporate and stakeholder interests, but to have them be your advocate and support.

Questions for the panel:

Eugene Brown of VPI asked the panel to discuss the challenges of working with universities.

Stephen Schutt talked about the health and safety issue. Who will assume the potential liability of graduate students working in an radioactive environment? From his experience working with VPI on a robotics project, Jim Gutzwiller spoke of the importance of having an enthusiastic sponsor at the university. The sponsoring professor had good relationships with his students, and he took Framatome's lead in clearly defining work scopes and setting up schedules. He managed to involve students to meet the goals and schedules of the project. Hank McGuire spoke of the lack of continuity resulting from either the university sponsor or students dropping out of the program. The quality of a program at Hanford with the University of Washington depended on the ability of the sponsoring professor to recruit students from one year to the next. DOE cost cutting has also affected the number of summer students involved in Hanford/University of Washington programs. Dale Keairns added that having champions on both the university and corporate sides is critical to the success of such programs. The intellectual property issues are important in large, integrated programs.

Rod Warner of DOE's Fernald Site asked how DOE can create incentives in its contracts, so contractors will use new technologies. George Brown suggested taking a system-wide look at the problem. We know that we can't completely clean up the complex for the level of resources we can realistically expect to put into it. So, the issue becomes examining the system and understanding where new technologies can make a major impact. Then, incentives can be redrawn, priorities restated, time investments made to meet schedule and milestone objectives at sites. A broader perspective is called for.

Hank McGuire suggested that the lack of coordination between EM-30, -40, -50, and -60 is creating conflicting goals. Their missions don't include using innovative technologies. What is needed is commitment from the deputy assistant secretaries of these programs to work together to meet the 31 DOE D&D needs.

8 Presentation of D&D Center of Excellence Concept

Paul Wieber described the D&D Center of Excellence concept and how it applies to university/industry collaboration on D&D topics.

Editors' Note: While the general concept of the the D&D Center of Excellence presented at the Workshop was and is valid, METC has made some changes in how it plans to implement the concept. The following text has been edited to reflect those changes. We believe it is more important to provide accurate and up-to-date guidance to potential participants, than to include the exact presentation from the Workshop.

The D&D Center of Excellence will be an industry-driven university research program to meet the needs of the D&D Focus Area. The overall objective of the Center is to encourage cooperation among DOE, universities, industry, and other government agencies, in university-based research that is cost-effective and relevant to the D&D needs of industry and federal entities responsible for the D&D of contaminated sites.

The model for the Center is the Advanced Turbine Systems (ATS) center, established by METC in conjunction with the South Carolina Energy Research and Development Center at Clemson University. The ATS center of excellence has been in operation for several years successfully bringing industry and universities together. The center currently has 30 to 40 active grants, and seven major companies sit on the industrial board.

This D&D Center of Excellence is envisioned to be a partnership, consisting of universities, DOE participants, member industries, and a suite of performing universities. The participants, in seeking improved mechanisms for bringing private sector based skills and technologies to assist the cleanup of the DOE sites, recognize the potential of an industry-driven university research program to support the development of better, faster, safer and more cost-effective D&D technologies. They are committed to realizing this potential by participating in, encouraging, and improving this Center.

Virginia Polytechnic Institute and State University, the University of South Carolina, the University of Cincinnati, and Florida International University will provide a university perspective and insure the research activities are also consistent with academic needs.

The intent of the program is to conduct R&D rather than build facilities. Therefore, existing facilities should be used to the greatest extent possible. For this reason, and to ensure that a site perspective is included in the program, discussions have been held with organizations responsible for potential D&D sites, and organizations that have testing facilities. Technologies may be tested at DOE's Savannah River Site in South Carolina, and the Fernald Site in Ohio. Testing of technologies related to human factors assessment may be conducted at the National Hazmat Site at Beckley, West Virginia which is operated by the International Union of Operating Engineers. Florida International University operates the Hemispheric Center for Environmental Technology, another potential test site. Institutions providing test and demonstration sites will endeavor, subject to specific arrangements, to make those sites available for research activities as appropriate and to facilitate and evaluate the operations on their respective sites. The above-mentioned universities and organizations responsible for the sites, as well as METC, will serve on an oversight board that will meet at least annually to evaluate the performance of the Center of Excellence in meeting its mission.

Identification of industry needs and assistance with proposal evaluation will be provided by an industry board. Participating companies will contribute to the support of administrative expenses and possibly other activities. Membership on the board will allow companies to

be involved in selection of D&D research topics used for solicitations, and selection of projects to address those research topics. To assure there is no conflict of interest, participants on the industry board will be ineligible for grants or contracts in the program. The intent is to include on the board companies who are potential D&D customers or D&D commercializers.

Once the Center of Excellence is operating, R&D needs will be identified by the industry participants. University and site participants will review these R&D needs and provide feedback from their perspectives. DOE will then work with the industry board to turn the R&D needs into topics to be issued in a solicitation. Universities, collaborating with industry and/or other laboratories, will be encouraged to submit proposals responding to the identified topics. Proposals will be reviewed by DOE, with industry participants as advisors, and selections will be made by DOE based on these reviews. Funded grants and contracts will be reviewed in annual meetings.

9 Working Group Topic Definitions

John Duda, Project Manager at METC, provided the guidelines for conducting the breakout sessions and presented the pertinent issues to be addressed by each breakout session. The participants divided themselves into four breakout groups based on interest: characterization, decontamination, dismantlement, and waste disposal and recycling options. Systems integration was a fifth breakout session that was added later.

The three questions participants were asked to consider while in breakout were:

- 1 . What are the industry needs for D&D research?
- 2 . What are the science-based programs through which universities will conduct their research?
- 3 . What universities are currently involved in relevant research and who are the university points of contact?

Before breaking for lunch, Duda introduced the facilitators and group leaders for each session and provided a map of breakout rooms.

10 Results of Breakout Sessions

Rita Bajura, Deputy Director of METC, was the master of ceremonies for the second day of the workshop. She told the participants the objective of the workshop's second day was to report on the breakout sessions and have a wrap-up session in which the major themes of the workshop would be pulled together. She said that universities interested in joining the TACO could simply give Gene Gardner of VPI a business card for his follow-up. The group leaders of the breakout sessions then presented the results of the breakout sessions.

Working Group 1 — Characterization

Facilitator: Floyd Crouse

Group Leader: Harold Shoemaker

Methodology: To get started and break the ice, each participant listed what they wanted to get out of the session. These ideas were recorded, formed the basis of the session, and reappeared as discussions became more focused.

DOE and commercial nuclear industry have common needs for characterization:

- Real-time characterization with DOE putting more emphasis on real-time characterization of tritium.
- Characterization of pipes, especially those that are encased in concrete; drains; ducts; cracks in concrete (How deep is the contamination?); behind walls.
- Improvements in air monitoring equipment to detect radioactivity. When taking core samples, radioactive particles may become airborne.
- Improved real-time sensitivity to determine when it's clean enough without going back to laboratory.

DOE's needs for characterization include:

- New sampling techniques for spills outside work areas
- Location and characterization of embedded objects. Older DOE facilities have drain lines that aren't identified on old plans.
- Software to compile and manage characterization data. For example, running statistical analysis on data to determine the logical place to collect data in subsequent characterizations.

Industries' needs for characterization include:

- Risk-based standards that specify allowable residual levels of radiation and hazardous materials. Develop criteria for free release of materials.
- Robotic characterization delivery systems. Robotics could reduce labor intensive costs and help obtain consistent results.
- Instruments to accurately characterize inaccessible, curved, or irregularly shaped surfaces
- Surface/volumetric changes affecting tritium. Taking a core sample, for example, may change the moisture in the air, the barometric pressure, which affects status of tritium contamination.

University opportunities for involvement:

The breakout session participants were not prepared to identify universities capable of researching particular research areas. However, they discussed in general terms universities' role in meeting the mutual needs of DOE and industry:

- The needs span all engineering and science disciplines, including electrical, mechanical, computer science, and chemistry. A multidisciplinary approach will be necessary.
- The selected research projects should represent true partnerships between industrial and university sectors and should produce outcomes useful to both. Any partnership between universities and industry must incorporate the university mission to train and teach students. A clear distinction must be drawn between student research and student-provided services to industry.
- Forming partnerships with industry through a TACO will facilitate universities working with contractors at DOE sites.
- Universities should conduct research that can be applied to develop standards for dose exposure to radiological and hazardous materials, organics, heavy metals, organic

solvents, etc. A risk-based approach to setting standards will help develop sensitivity specifications for characterization equipment and sensors.

- The Request for Proposals must be clearly written to specify required university expertise. For example, if characterization of radionuclides is required, this must be specified since universities have limited experience working with radioactive materials. Inclusion of key words would be useful, so universities can determine if they are knowledgeable in those areas. Non-technical staff evaluate and review RFPs and may not pick up on the entire scope of work if the language of the RFP is vague.
- To meet needs of universities, expand the concept of the TACO to include all focus areas.

Other discussions during the breakout included:

- Characterization is the first step to solving decontamination problems and also needs to be performed at the end of decontamination to measure residual contaminant levels. Characterization determines what contaminants are present, their amounts, and locations. Characterization also determines if contaminants are hazardous, toxic, ecologically damaging.
- The group expressed the hope that the TACO or a group of universities would define characterization needs in terms of specific contaminants.
- How much characterization is too much? At some point, the materials need to be disposed. A balance needs to be established between characterization processes and disposal.
- The group wished to have another workshop to discuss specific hardware and software to improve characterization. The group was disappointed this workshop was not the forum to address new and improved instrumentation and robotics. However, this workshop does serve as a stepping stone to further collaboration among federal agencies, industries, and universities.

Questions/Comment:

Bob Bedick, METC: Any discussions on sample preparation or delivery of samples to the analytic instruments?

Answer: There was some discussion but not very much detail in that area.

Working Group II — Decontamination

Facilitator: D. Denise Riggi
Group Leader: Paul Hart

Methodology: First, the group held a freeform discussion, which covered current general D&D needs, as well as some current research being conducted at Florida International University, University of South Carolina, and the University of Pittsburgh. The group then determined which needs, as outlined and prioritized by the 1996 D&D National Needs Assessment, pertained to industry as well. From the DOE list of 31 D&D technology needs, eight pertained to decontamination. Two of these eight needs were determined to be common to both DOE and industry and of equal importance to industry.

DOE D&D and industry needs:

1. Concrete decontamination (Priority # 6)
2. Metal decontamination (Priority #2)

For concrete decontamination, the major areas for research and development were determined to be:

- Minimize airborne contaminants during decontamination operations.
- Remove minimal amount of matrix when removing contaminant to minimize final waste volume. This practice will lower disposal costs.
- Minimize secondary waste for liquid decontaminations.
- Protect worker while maintaining productivity.
- Develop user-friendly decontamination technologies.
- Integrate characterization and decontamination technologies in real time. This means that during decon operations, worker would be aware, through real-time characterization, when decontamination had been accomplished. Minimal removal of material would be the result.
- Integrate better containment systems into decon operations.
- Understand chemical nature of contaminants to allow for the design of better removal technologies.

For metal decontamination, the major areas for research and development were determined to be:

- Minimize airborne contaminants.
- Minimize final waste volume.
- Minimize secondary waste.
- Subsets, including:
 - Removal of lead-based paints
 - Locating and removing underground and encased piping
 - Mercury decontamination, especially in nickel. (This is a DOE need, as opposed to industrial need.)
- Containment interaction with metal surfaces
- Solution chemistry of contaminants (liquid decontamination)

University capabilities that could be applied to meet needs:

Three universities were represented in the breakout session. University of South Carolina and Florida International University have a long history of working within DOE's

Environmental Management program at DOE-EM sites. University of Pittsburgh has experience with Westinghouse Science and Technology Center, which is involved with work for the DOE complex, in the commercial nuclear industry, and D&D activities.

University of South Carolina's expertise and resources include:

1. Robotics
2. Separations, filtration to apply toward liquid decontamination
3. Electrochemistry
4. A NIST Southeastern Manufacturing Technology Center for the integration of technologies

Florida International University's expertise and resources include:

1. Non-radiological testing area for evaluation of technologies
2. Facilities and track record to quickly modify existing technologies to meet specific DOE or industry needs
3. Focus on waste minimization and improved final waste forms (NAC)
4. Developing a relationship with South and Central American industries in meeting environmental needs

The University of Pittsburgh's expertise and resources include:

1. Advanced Material Research Center
2. Surface science
3. Solid waste disposal in the environmental area
4. Worker radiation protection
5. Fluid particle systems, which is related to decontamination and separations
6. Biological and biomedical sciences
7. Flexible Manufacturing Center for integration of technologies into systems and worker training

The participants also discussed other universities and what they could offer in the area of decontamination. Other universities and consortia mentioned were:

1. South Carolina Universities Research and Education Foundation (SCUREF) works with the Savannah River Site (SRS).
2. Similar group of Georgia universities centered around Georgia Tech works with SRS as well.
3. The University of Cincinnati works with the DOE's Fernald Site in Ohio.

Comments/Questions:

Jim Byrne: Any discussion of volumetric decontamination?

Answer: I don't think we did. Is that a big problem for nuclear utilities?

Byrne: Yes

Answer: Okay, then, we need to capture that as another subset.

Working Group III — Dismantlement

Facilitator: Cliff Carpenter

Group Leader: John Duda

From the DOE list of 31 D&D technology needs, six needs are associated with dismantlement:

1. Dismantlement of large/complex equipment and structures (priority #1)
2. Dismantlement of process equipment and structural materials (priority #9)
3. Worker protection clothing (priority #11)
4. Improved roof system and roof maintenance techniques (priority #16)
5. Dismantlement of concrete encased piping (priority #22)
6. Raschig ring removal (priority #23)

Methodology: Industry members of working group III were asked to think about their dismantlement needs in terms of the above six DOE needs. During silent generation, industry representatives wrote on Post It notes specific needs related to the six DOE needs. Twenty discrete needs were identified and posted on charts under the appropriate DOE need. The industry participants then ranked their needs by placing dots against the needs they believed represented the greatest priorities. Later, university representatives discussed their capabilities and expertise. Although university capabilities didn't directly match needs, university competencies crosscut the various need areas.

From the discussion, five general themes emerged:

1. Begin research now for dismantlement of highly radioactive areas. This is important because of the long lead time for this type of research.
2. DOE needs and industry needs are consistent.
3. DOE should define for the university community the science-related end products they are seeking.
4. Some members of working group III expressed needs for changes in policy, regulations, and training as opposed to strictly science-based needs.
5. Most needs can be accomplished by incremental improvements instead of requiring large leaps.

Specific industry needs (in priority order) as related to DOE D&D needs:

Dismantlement of large/complex equipment and structures (priority #1)

1. Improved cutting techniques to minimize secondary waste. Need more effective magnetite, rebar, and concrete cutting/breaking devices.
2. Streamline the very complex DOE hoisting and hauling guidelines to be more closely aligned with industry practice.
3. Operator involvement sooner in the design phase of technology development.
4. Improved asbestos removal techniques
5. Improved dust and other contaminant abatement or confinement
6. Establishment and communication of baseline technologies and on-going research to develop innovative technologies

Dismantlement of process equipment and structural materials (priority #9)

1. Precise characterization of internal contamination of pipes and tanks in order to know what engineering controls will be necessary and sufficient during D&D.
2. Extend capabilities of robotic manipulators, so can more robustly deliver a heavier payload.
3. Determine the best approach to dismantlement: system by system or area by area. Allow flexibility where appropriate.
4. Establish emergency response procedures and training for dismantling. These procedures may be in place for place general operations activities, but for catastrophic events during dismantlement, different procedures may have to be instituted.
5. In-place removal of lead-based paint and separation of contaminants to allow for free release of structured steel.
6. Investigate alternatives for size reduction, such as cryogenic or explosives.

Worker protection clothing (priority #11)

1. Investigate the benefit of DOE creating a mobile work force to supplement workers at sites.
2. Determine when control of work environment is more effective, efficient, and protective of worker than control of worker's immediate environment.
3. Consistent application of environmental safety and health standards across the DOE complex.
4. Training to increase donning and doffing efficiency and to standardize decontamination procedures. Determine what process changes, such as people to help workers don and doff protective clothing, would be value added components.
5. Better protective clothing and supplied air systems.

Improved roof system and roof maintenance techniques (priority #16)

1. Wide-spread deployment of state-of-the-art roofing systems. Identify, compile, and disseminate information on what is state-of-the-art.
2. Continue development of thin layer thermally sealed roofing, other coatings and cladding materials.

Dismantlement of concrete encased piping (priority #22)

1. Detection of underground and embedded piping. Whether drain piping or process piping, the plans showing these may have been lost. The question becomes determining the location, mapping and removing these pipes, instead of tearing out the whole floor. This will reduce costs.

Raschig ring removal (priority #23)

Not an industry need.

University capabilities that could be applied to meet needs:

Robotics Development

- Software development and control systems for lighter and more mobile robots, platforms, and manipulators
- Higher performance batteries, miniaturization of batteries, and longer-life batteries for propulsion systems

- Hardware systems development, including telescoping manipulators, long-reach type arms, flexure control, stiffness, different mobility aspects, degrees of freedom, handling higher payload systems

Improved Systems

- Sensors for scanning and detecting
- Data analysis, processing, and algorithms
- Remote imaging and display
- Artificial intelligence, “smart” systems
- Non-destructive inspections
- Sensor-guided manipulation

Materials Science

- Composites (applied to roofing systems)
- High tech coatings and cladding materials
- Automated inspection and analytical device systems
- Studies of the effects of radioactivity, temperature, and stress on materials

Worker Protection

- High radiation suit to protect worker and to overcome cost and time of remote operations
- Comprehensive study to develop efficiencies in training and standardize decontamination procedures across the DOE complex.
- Industrial hygiene research — health risks and environmental contamination data analysis to provide input to policies and regulations
- Human factors analysis to crosscut all areas of D&D

Liquid Waste Processing

- Filtration processes

Comments/Questions:

Rita Bajura: During the breakout session on characterization, a comment was made that research should first be directed toward low contamination activities of commercial nuclear power plants, because the volume of low contamination is greater, so an improvement there would have a greater impact on cost and time expenditures.

Answer: We can dismantle, but we want to do it cheaper and at less risk to workers. This workshop focused on university involvement and they are concerned they be given an adequate lead time. They expressed a focus on the high rad area.

Working Group IV — Waste Disposal and Recycling Options for D&D Materials

DOE Facilitators: Madhav Ghate

Group Leader: Steve Bossart

Methodology: The discussion began with a free form discussion on “Recycle/Disposal” issues covering the areas of:

1. Risks
2. Needs
3. Policies (DOE)
4. Stakeholder perceptions

From the list of ideas generated, further consideration was given to research ideas that could appropriately be carried out by universities. These ideas were prioritized by the following criteria:

- Cost, contribution to mortgage reduction
- Near-term needs, those that need to be addressed quickly

University research ideas discussed included:

(top three priorities)*

1. * Develop long-term in-situ monitoring techniques for disposal cells (e.g., wells) (A DOE expressed need).
2. * Develop real-time characterization during D&D operations for disposal/recycle options to determine when target decontamination level has been reached (Both a DOE and commercial need).
3. * Develop facility characterization for final survey/verification of cleanliness to release the facility (Both a DOE and commercial need).
4. Develop consistent life-cycle cost methodologies for recycle versus disposal options.
5. Establish a process for building stakeholder confidence in risk acceptance for both recycling and disposal options.
6. Optimize low-cost containers and disposal cells, including using materials generated from D&D to make new containers.
7. Develop new recycle technologies, especially for metal and concrete.
8. Analyze market for isotope recovery and recycle.
9. Analyze market for heavy metal recycle.
10. Minimize secondary waste generated during D&D operations to reduce disposal volume.
11. Identify opportunities for potential reuse of existing and future DOE facilities. Could materials from D&D operations be reused to build new DOE facilities?
12. Develop remote automated sorting and handling to segregate low-level from high-level, radioactive from non-radioactive, and hazardous from non-hazardous materials. Process and containerize waste as it is generated during D&D operations.
13. Conduct paper studies on reuse of recycled materials in future D&D facilities
14. Research DOE's liability for turning over ownership of its radiological materials for recycling to the private sector.
15. Enhance transport models for disposal cells.
16. Facility characterization to support D&D planning, specifically to help decide which materials are eligible for recycling within DOE and which materials are candidates for disposal.

17. Establish cold test facility for operator training on D&D equipment and for evaluating technologies.
18. Educate future generations of D&D professionals.
19. Investigate the reuse of personal protective equipment (PPE) and reduction of heat stress of PPE.
20. Conduct radioactive decay studies for materials in disposed or recycled states.
21. Characterize materials to determine what attributes make them conducive to disposal or recycle options.
22. Industry could identify products that could be made from recycled materials, determine optimum uses for recycled products, and develop performance specifications for various recycled products.

Although on-going university research is probably not direct D&D research, it's possible that university research could be applied to D&D. The group suggested investigating yearbooks and reports of the following organizations to get a better understanding of possible links between current university research capabilities and D&D needs for research:

- American Society of Engineering Education (ASEE) yearbook
- American Institute of Chemical Engineers (AIChE)
- National Science Foundation (NSF)-sponsored work
- IUERC

Known, on-going university work:

- Separation techniques to sort rad from non-rad and hazardous from non-hazardous
 1. West Virginia University
 2. Colorado School of Mines
 3. University of North Dakota Energy & Environmental Research Center (UNDEERC)
- National Regulatory Commission (NRC):
 4. National Institute of Standards & Technology (NIST) — Building Materials Division (concrete durability)
 5. University of Arizona — Long-term monitoring strategies

Questions/Comments:

Paul Wieber: The cold test facility in Beckley, West Virginia will probably meet the need presented in number 17.

Vincent Van Brunt: Related to investigating what university research is currently being conducted, the University of South Carolina is building a database of chemical engineering expertise that could serve as a source of information.

Working Group V — Systems Integration

Facilitator: Dr. Wolt Fabrycky

The theme for the breakout session was the mission statement of the D&D focus area, which refers to “improved technologies and systems” and “these technologies and systems.”

The breakout group identified the following systems problems:

- Technologies are being evaluated based on individual merit alone, instead of their merit in the overall D&D system.
- Consideration of everything on a life-cycle basis is not yet adopted within D&D.
- Conformance to standards (e.g., ISO 14000, the new environmental guidelines) is not yet viewed as system requirements.
- Capturing externalities during the design process as a means to consider the entire system problem must include the public’s perception.
- Integrating “knowns” may not meet needs due to a lack of top-down design control.
- Requirements deviation to assess trade-offs and evaluation of alternatives for acceptability is not yet incorporated.

There was considerable discussion about the nature of the systems approach. Is the D&D process with a focus on outcomes the system? Or is the system the individual technologies themselves? The purest form of systems engineering says that the system is to meet a functional need through transformation as in Figures 2 and 3. For the EM program, the transformation converts unacceptable environmental products into environmentally acceptable products. Specific topics for attention are:

- What kind of project (research wise) is appropriate for this problem? There seems to be agreement that systems integration is valuable and necessary for D&D. But, the systems approach takes patience. DOE has not been patient in the past to implement the systems approach.
- What projects? Deactivation versus decommissioning? Steps for decontamination: What type of material? Identify the product. Identify performance. Can this material be mined, characterized for particular reuses, and what effects of reuse, etc. to the economy, training, society as a whole, etc.
- There’s really no grave to the “cradle to grave.” The effects of development of systems and decisions continue on into perpetuity.
- DOE considers societal concerns as part of design, implementation, and disposal phases. Systems engineering incorporates these too.
- System development and integration requires steps, such as technical feasibility, criteria development, and evaluation of alternatives. The challenge is to capture fuzzy requirements in a way that is useful and that can drive the systems design process.
- The systems approach should be a vehicle for identifying the desired technological capabilities. The technologies should not dictate what the D&D mission should be, only what it could be. The functional need must dictate the development and implementation of the technologies.
- Is process technology research a viable and appropriate topic and area for research at this workshop?
- We must not busy ourselves with “doing things right,” but rather we must “do the right thing.” What is the right thing?

- Many tools and processes have been developed already. Is this new research or just application of existing knowledge to new problems? It needs to be done. But, is this research? Are education and training what are needed?
- The question is who is to be satisfied? Who decides that the system design is a success or that the mission objectives have been achieved?
- Systems engineering has the ability to “rope” or get a handle on the problem being solved, categorize the problem, and allocate and include various disciplines.
- What incentive is there for DOE to adopt this approach? Is it worth it?
- The problem becomes defining the scope of the problem. What constitutes the system? There should be a template, a list of D&D systems issues, that can guide the development of D&D systems to ensure that the mission can be fully accomplished.

System research needs include:

- Develop a systems engineering framework for the D&D process (overall research project).
- Develop a systems engineering template for guiding DOE and in particular D&D. The most important thing is education about the systems approach.
- Design and develop computer-based tools for evaluating the desirability of D&D alternatives and for comparing on a optimal, fair, and equivalent basis.
- Software engineering is analogous to the design problem of D&D. Software engineering is a specific implementation of systems engineering. The process is tailorable to the implementation. Can this be the same for the D&D problem?
- Define and develop specifications for customer needs and compliance requirements in the D&D process, including the different value systems of the stakeholders.
- Develop a systems approach to deal with the dynamic changes that occur in D&D system parameters over time.
- DOE needs a system assessment capability to support continuous improvement, and systems engineering can meet this need.

11 Closing

In summarizing the workshop, Rita Bajura mentioned two major themes. Industry has needs that universities can solve, and universities have capabilities that can be used to solve industry needs. The trick is putting these two together.

The workshop generated different lists of possible research topics. They fell into three categories: science-based needs, broader areas of applied research, and issues Bajura believed could best be addressed by others, such as regulatory codes and standards and certain aspects of systems analysis and systems engineering. Universities, for example, are not intimately involved with the proprietary cost factors that a private-sector contractor might use to develop the cost of doing a D&D project. Therefore, in certain aspects of doing a systems analysis, universities might be disadvantaged. Industry can help define and select those specific, detailed technical areas where the university has an appropriate role.

For the Advanced Turbine System/university consortium, it was eventually resolved that the university worked on non-proprietary research, research that could be published and presented to the world. Companies who cost shared and owned intellectual property rights to certain research reserved proprietary research for themselves. One of the initial follow-ups to this workshop will be to begin defining the TACO ground rules.

University help is needed to define the ground rules for the TACO. Industry can provide the needs, but the university community has to define which needs are applicable to the university and the mission of the university. Facilitating university interaction can be as simple as awarding two-year grants so students have time to complete and write their theses. Another consideration might be timing the awarding of grants so students are available to begin research on September 1. University input on ground rules is needed for the TACO to work well for the benefit of both industry and university participants.

Holding two annual review meetings has worked well for the ATS/university consortium. At a peer review annual meeting, university researchers present their research program and their peers critique their methods for conducting research. The purpose of the second meeting is for industrial sponsors to evaluate the merit of research projects. Industry decides if universities are researching the right topics and how the research contributes to solving bigger problems.

Bajura said one of the themes she did not hear coming from the workshop was the need to do research in a more cost effective manner. The days when the government built large fixed research facilities is drawing to a close. As envisioned for this TACO, the D&D center of excellence is a virtual laboratory and as such is a cost effective solution to conducting research.

Another aspect of containing costs is eliminating duplication of efforts by building on research that has gone before. In this regard, Bajura mentioned the importance of using off-the-shelf equipment. Appropriate research for universities might be to use a commercially available robot to see how it can be modified to meet particular needs. Another example is researching the interface between two existing computer codes, but not developing new code from scratch.

What happens next? The information gathered at this workshop will be assembled into a report for distribution to all attendees. DOE will evaluate the proposal to establish a D&D Center of Excellence.

Comments/Questions:

Wolt Fabrycky questioned Bajura's assessment of the role of systems analysis in the TACO. Bajura expressed the opinion that universities are well suited to developing the tools to do systems analysis but are less well suited in applying those tools and supplying the precise parameters. For example, industry is best qualified to conduct performance estimation and cost estimation, because those are proprietary functions. Bajura also said EM is already supporting many other systems analysis projects, but these activities are unsatisfactory because they are not giving the senior management of the EM program the answers they need to make rational decisions.

Rod Rimando, DOE Savannah River Operations Office, argued for the inclusion of other entities in the TACO. He mentioned pharmaceutical companies that use radioactive isotopes in medical research and liberal arts departments of universities that could record history and preserve artifacts of DOE's 50-year experiment of closing the circle on nuclear weapon production.

Bajura agreed that the business, biomedical, and legal communities could play a part in this project.

Attachments

University Capabilities

Florida International University Hemispheric Center for Environmental Technology

The Hemispheric Center for Environmental Technology (HCET) coordinates all activities related to the DOE-FIU partnership and focuses on environmental technology development with partners in Central, South American and the Caribbean nations. All 250 faculty members of HCET have the potential to contribute research to support a D&D center of excellence. Research would include such areas as examining health and safety aspects of environmental technologies, decontaminating pipes, and dust control.

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HCET's home page - <http://www.fiu.edu/~hcet>

Medical University of South Carolina

The Medical University of South Carolina (MUSC) has the distinction of being the oldest medical institution in the southern United States. Since its beginning in 1824, the university has grown from a small medical school to a health professions institution comprised of a 600-bed referral and teaching hospital and six colleges: Medicine, Pharmacy, Nursing, Graduate Studies, Health Professions, and Dental Medicine. The university offers a full range of programs in the biomedical sciences and stands at the core of the state's largest medical complex.

Institutional support of critical research technologies in shared facilities makes equipment and expertise accessible that may not be feasible or cost-effective for individualized operation. These include DNA and peptide synthesis and sequencing, flow cytometry, mass spectrometry, spectroscopy, protein chemistry, nuclear magnetic resonance capability, electron and confocal microscopy, and image processing and analysis. Highly specialized facilities include:

- MUSC's Mass Spectrometry Facility – One of the best equipped protein mass spectrometry laboratories in the world. Instrumentation includes a high mass, high

performance tandem mass spectrometer (one of only three such instruments in US universities), a triple quadrupole tandem mass spectrometer and a matrix assisted laser desorption time of flight mass spectrometer.

- Photon Counting Facility – Designed around a Hamamatsu Photon Counting System, this core facility provides capability for real-time measurement of gene expression in living cells and repeated measurements in the same cell.
- Transgenic Mouse/Gene Knock-out Facility – Providing extensive tissue culture facilities to select, analyze and maintain genetically engineered cells at a very high level of containment.
- Tumor and Tissue Bank – Including advanced equipment for environmentally safe dissection, preservation, histologic analysis, cell dissociation and primary culture, controlled freezing and low temperature storage of tumor and tissue samples.
- Pharmaceutical Development Center – One of only two such facilities at academic centers in the U.S. This industrial-quality product development centers is an FDA-accredited facility operating under Good Manufacturing Practices (GMP).

The Medical University has research capabilities worthy of consideration in many aspects of Decontamination and Decommissioning (D&D) Research and Development (R&D). Certainly, the primary areas are in human health concerns. However, there are other areas such as bioremediation and monitoring and detection where the University has substantial capabilities that could be a valuable part of team efforts. The areas for consideration include:

- Worker Health:
 - Medical surveillance: development of protocols
 - Monitoring and exposure analysis: personal exposure monitoring, biomarker development, exposure analysis
 - Health protection and industrial and personal hygiene: identification and analysis of exposure pathways, development of preventive measures in both engineering and personal behaviors, worker training for effective prevention
 - Health care needs: development of treatment protocols for exposed workers
- Public Health:
 - Monitoring and exposure analysis for individual members of the public
- Bioremediation:
 - Development of specific bioremediation capabilities
- Community Involvement:
 - Education of health care professionals and the public on the health aspects of D&D technologies and clean-up activities.
- Monitoring and Detection:
 - A number of researchers and facilities such as the high performance tandem mass spectrometer with the capabilities for detection at the cell level which could be utilized in a number of projects in detection and monitoring of contamination.

The most likely MUSC groups to focus on D&D applicable research are:

Department of Environmental Health Sciences: analysis of worker and patient exposures to radioactive and chemical elements, microactivity analysis, utilization of GIS modeling, worker health protection training and medical surveillance.

Department of Biometry and Epidemiology: epidemiological studies of worker health, risk assessment, modeling of biological systems.

Department of Family Medicine, Occupational and Environmental Medicine Program and Agromedicine Program: worker health medical surveillance protocols, exposure analysis and health effects, education of health care professionals.

Department of Cell & Molecular Pharmacology and Experimental Therapeutics: Monitoring and detection (mass spectrometry), toxicology, biomarker development, physiologically-based pharmacokinetic modeling.

Department of Microbiology and Immunology: bioremediation of VOC's and PCB's, genetic mechanisms of environmental hazards.

Environmental Hazards Assessment Program: a cross-cutting program supporting a wide range of collaborative efforts in environmental education and research. The Program's faculty and staff have expertise in community education and involvement.

In addition to the faculty and staff, there are a number of graduate students in various programs who are actively involved in environmental research. These students and others in programs throughout campus provide a valuable resource to all the research efforts in the University.

For further information, please see the Medical University's world-wide-web site at The primary point of contact for this program of research is:

For more information contact:

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MUSC's home page - <http://www.musc.edu/>

Pennsylvania State University

The University has 15 major intercollege research programs that are responsible for one third of all the research conducted at the university. Of these programs, the following would most likely respond to D&D proposals.

Materials Research Laboratory

Research areas include investigations of theoretical and applied physics, measurements of ferroelectric, dielectric, optical and thermomechanical properties of materials, and investigations of materials synthesis and processing that include thin film deposition, high pressure synthesis, low temperature synthesis and high temperature ceramic processing. The laboratory houses characterization facilities with special emphasis on ellipsometry, x-ray powder diffraction, electron microscopy and vibrational spectroscopy. Much of the research has direct ties to industry. Many investigations are interdisciplinary in the broadest sense, including design and synthesis of materials suitable for the encapsulation and immobilization of nuclear and chemical waste and other environmentally related problems.

Environmental Resources Research Institute

Using a multidisciplinary approach, the Institute coordinates and conducts basic and applied research on environmental problems. Faculty from Agricultural Sciences, Earth and Mineral Sciences, Education, Engineering, Health and Human Development, and the Eberly College of Science collaborate on projects. Current programs focus on acid mine drainage and mineland reclamation, environmental impact assessment, hydrologic and environmental systems modeling, risk perception and public education, residuals control technology, bioremediation and detoxification, and health and toxicology

Applied Research Laboratory

The Applied Research Laboratory (ARL) is a Navy-oriented research facility established in 1945 to advance the Navy's technology base through basic and applied research, and through exploratory and advanced development. ARL brings technology to bear on a range of environmental compliance and monitoring problems. One research area involves using laser-based methods for the neutralization, incineration, and removal of toxic materials. Work is in progress, for example, to find the electromagnetic wavelengths most effective for breaking down volatile organic compounds and PCBs. ARL has perfected methods for safely cutting asbestos for removal and is now developing methods for removing alkaline metals, such as lithium. Researchers are also developing alternatives to chemical coating and joining processes that require highly toxic materials. Laser welding of electronic components has been shown to be an effective replacement for standard soldering processes. Laser-based cladding has the potential to replace standard cladding processes, and laser paint stripping is under development.

Particulate Materials Center

The Particulate Materials Center is dedicated to supporting members' interests by establishing engineering and scientific foundations for the manufacture of advanced products from particle systems. Major emphasis areas include particle formation, powder processing, and consolidation technologies. Researchers are applying and developing new techniques for characterizing particle behavior at all levels of manufacture; developing computational tools for efficient process simulation and evaluation; and implementing these methods for advanced process understanding and improved product manufacture.

Faculty Conducting Research in Areas of Potential Interest

Department of Civil and Environmental Engineering

- **Donald W. Christensen** - Construction materials; materials science; quality management in construction materials laboratories; use of industrial wastes in construction materials.
- **Christopher J. Duffy** - Stochastic and numerical modeling of groundwater flow and solute transport, modeling large-scale hydrologic systems.
- **Theodor Krauthammer** - Structural concrete mechanics and dynamics, earthquake and blast engineering, numerical and symbolic methods of analysis.
- **Archie J. McDonnell** - Water quality models, environmental models, transport and fate of contaminants in aquatic environments.
- **Raymond W. Regan, Sr.** - Environmental pollution control, solid and hazardous waste management, biological waste treatment, beneficial use of industry residuals.
- **Andrew Scanlon** - Safety and serviceability of concrete structures, analytical modeling of concrete structures, structural dynamics, earthquake engineering.
- **Paul J. Tikalsky** - Concrete and cementitious material properties, behavior and evaluation; nondestructive and in-situ testing of structures and materials; high performance concrete; reinforced concrete design and construction.
- **Mian C. Wang** - Geotechnical engineering, geotechnical aspects in solid waste disposal, soil testing/evaluation, foundation design and analysis.
- **Gour-Tsyh Yeh** - Groundwater hydrology, surface water hydrology, waste management, numerical analysis, geochemical modeling, fluid mechanics.

Chemical Engineering

- **David J. Cannon** - Professor Cannon is developing a Virtual Reality-based Point-and-Direct (VR-PAD) robotics system for hazardous waste remediation. The concept is also funded as an enabling technology for agile manufacturing where setup, rapid flexible modification, and quick error recovery are required. He teaches courses in robotics and control theory.

Nuclear Engineering

- **William A. Jester** - Radionuclear techniques, such as activation analysis, for the solution of scientific and engineering problems and the development of environmental radiation monitors and instrumentation.
- **Barry E. Sheetz** - Waste form development, stability and environmental interaction, cement and concrete for immobilization and isolation of wastes, cement chemistry,

nuclear and hazardous chemical waste management, crystal chemistry and materials characterization.

- **Marcus H. Voth** - Reactor operation, applications, safety, instrumentation, radioactive waste disposal.

Mineral Engineering

- **Raja V. Ramani** - Mine safety; flow mechanisms of air, gas and dust through mining systems; development of innovative mining methods; simulation and mathematical programming; equipment selection, productivity and management issues; environmental planning; integration of land-use planning and surface mine planning.

Mining Engineering

- **L. Barry Phelps** - Reclamation; selective placement; burial of toxic material; re-mining with pre-existing pollutional discharges; slope stability; mathematical modeling and erosion; sediment control.

Geochemistry

- **Rustum Roy** - New materials preparation and characterization; crystal chemistry, synthesis, stability, phase equilibria and crystal growth in non-metallic systems, ultrahigh pressure reactions in solids; radioactive waste forms; Nanocomposites; science and public policy; science, technology and human values.
- **William White** - Infrared and Raman spectroscopy; crystal chemistry and phase equilibria; optical ceramics; glass structure; aqueous chemistry; mineral physics; hydrogeology and geomorphology of carbonate terrains; environmental geochemistry; nuclear waste research.

For more information, contact:

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Penn State's home page - <http://www.psu.edu/>

University of South Carolina

The University of South Carolina has developed a long-term relationship with U.S. DOE facilities, particularly with the Savannah River Site (SRS). Active Environmental Restoration/Waste Management (EM) projects are in most focus areas and crosscutting programs. The faculty have experience in providing practical engineering solutions that take into account the multifaceted nature of D&D.

For example, College of Engineering researchers were asked to develop a sewer degreaser to improve the performance of a 2000 psi water flush system that could be effective for both concrete and metal piping. The resulting emulsion-based solvent provided rapid cleaning with increased loading. By using an emulsion rather than a homogeneous solvent, high efficiency with little waste burden was achieved. It was fast, easy to use, biodegradable, and compatible with the water flush system seals and piping. Further, it did not pose a significant toxic or flammability hazard. It was worker friendly. The solvent was developed at the bench and then reduced to practice in less than two years. Full-scale testing was conducted in the Columbia, South Carolina sewer system.

Engineering programs in robotics, manufacturing, and separations (including a pilot-scale facility for crossflow filtration) and their applications to radioactive environments and for partitioning of high activity liquid waste are currently funded by the U.S. Departments of Energy and Defense, and the National Science Foundation. Tritium recovery from aqueous process streams is also being studied. Sensors for chemical concentration measurement, processes for recovery of RCRA metals, cations, and anions are being developed by the electrochemical engineering group. Groundwater monitoring and modeling and the properties of concrete are being studied in civil engineering and in mathematics.

The robotics program is part of ARIES (Autonomous Robotic Inspection Experimental System). Funded through METC, it is a consortium of university and industry representatives engaged to design, build, and test a radiation-hardened, complex mobile robot for drum inspection. It is anticipated that the ARIES robot will be useful for D&D activities.

Civil engineering researchers are developing ways to evaluate the structural damage to concrete during decontamination. The electrochemical research group is studying the removal of chromium and of radioactive species using mass transfer combined with electrochemical processing. This research exploits the high efficiency electrical potential for decontamination and corrosion control.

Other D&D-related research areas include:

- Chemical Engineering - electrochemical engineering studies: batteries; corrosion studies: cathodic protection of steel, epoxy coatings; and filtration techniques: removal of contaminants from waste stream prior to vitrification
- Civil and Environmental Engineering - radiation and temperature effects on concrete; corrosion: bridge structures in marine environment.
- Mechanical Engineering - non-destructive evaluation: fatigue, fracture in aging aircraft and other applications; materials: metals and fiber-reinforced composites.

For more information, contact:

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University of South Carolina's home page - <http://www.csd.sc.edu>

University of Tennessee

Hydraulic manipulator design and control of large payloads
Flexure control in long-reach manipulators
Redundant kinematics for complex load handling
Sensor-guided manipulation for precise control of mobile robot work systems
3D in-situ geometry characterization
Smart scene 3D scanning
Human-interactive stereo 3D scanning
Mobile robot navigation and control
Computer vision-based inspection
Telerobotics control for combined manual and automatic system operation

For more information contact:

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The University of Tennessee - Knoxville
207 Dougherty Engineering Building
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Virginia Polytechnic Institute and State University

Virginia Tech has a wide variety of expertise and facilities for research in D&D-related activities. This list is representative, but not all-inclusive.

Biology

Biological assessment and monitoring of contaminated surface waters - E.F. (Fred) Benfield

Ecological restoration, ecotoxicology, policy on sustainable use of the planet - John Cairns

Remote sensing - Jim Campbell

Chemical Engineering

Materials science, ceramics, metallics, smart materials, etc. Polymeric adhesives and composites, polymer synthesis, inorganic thin films, sensor devices, fiber optics, shape memory materials and membranes - Garth L. Wilkes.

Polymer materials, polymeric systems including synthesis, structure and property characterization and processability. polymerization, vitrification, membrane technology and general - (Polymer Materials and Interfaces Laboratory - 19 faculty across 6 departments)

Water removal, macroencapsulation, polymerization, vitrification, filtration, membrane technology, ion exchange, carbon absorption, organic separation - Rick Davis

Chemistry

Gel and membrane technology, thermodynamics of polymer solution, morphological characterization - Herve Marand

Measuring contaminants such as heavy metals in ground and surface water - Gary Long

Organic separations, identification, and quantification, supercritical fluid extraction of lanthanides and actinides water and solid matrices - Larry T. Taylor

Polymerization chemistry, membrane technology and organic separations - Harry W. Gibson

Spectral analysis, laser ablation methods, spectrometry - Brian Tissue

Civil Engineering

Acoustic Piezocone for enhanced site characterization, waste containment barriers, soil-waste interactions, remediation - James K. Mitchell

Biological reactor systems for biodegradation of hazardous compounds, especially mixed waste - Nancy Love

Contamination of soil and groundwater, in situ treatment, soil vapor extraction, air sparging, microbial degradation, engineered bioremediation, intrinsic bioremediation, contaminant transport, computer modeling, site characterization, monitoring, dewatering, and groundwater recovery - Mark A. Widdowson

Cost-effectiveness studies for innovative restoration technologies in-situ vitrification, in-situ bioremediation - W. Eric Showalter

Environmental sampling and monitoring, and modeling contaminant fate/transport/remediation - Dan Gallagher,

Finite element modeling of pollutant transport through soils, multi-phase transport of oil & water flow in leaking, underground storage tanks, landfill designs, geosynthetic liners, seepage analysis, geotechnical engineering - T. Kuppusamy

Infrastructure assessment and management - Richard Weyers

Microbial processes for degradation of hazardous organics, microencapsulation, water and wastewater treatment processes including both physical/chemical (ion exchange, chemical precipitation, chemical coagulation) and biological, solid/liquid separation process - John T. Novak

Nondestructive evaluations, infrastructure condition assessment, ground penetration radar applications - Imad L. Al-Qadi

Physicochemical and biological treatment systems, hazardous waste and environmental toxicology, toxicity assessment and treatment of heavy metals and organic substances - Gregory D. Boardman

Surveying and mapping, global positioning systems, land information systems, geographic information systems, remote sensing, and hydrology - Richard Greene

Use of geosynthetic materials to contain hazardous waste - Raymond H. Plaut

Computer Science

Image processing, remote sensing, robotics, contaminant modeling - Layne Watson

Crop and Soil Environmental Sciences

Using microbes for bioaccumulation, solubilization, and oxidation of radioactive materials - Charles Hagedorn

Engineering Science and Mechanics

Computer code for life prediction, durability, and damage tolerance of materials and material systems - Ken Reifsnider

Remote sensing and robotics - Demetri Telionis

Geological Sciences

Geochemical barriers to contaminant migration - Don Rimstidt

Groundwater flow and modeling, aquifer mechanics (including vertical and horizontal strains and earth fissure development due to pumping; land subsidence) contaminant transport modeling in groundwater flow systems including both advective and dispersive flow regimes, hydrogeological characterization and evaluation of hydrological parameters - Thomas Burbey

Remote sensing (subsurface imaging by geophysical methods such as seismic and ground penetrating radar), spectral analysis for geophysical/geological data - Cahit Coruh

Spectral analysis (computer methods, window techniques), groundwater (flow, modeling, numerical methods, physical principles) - John K. Costain:

Vitrification process, comparing D&D glass products with natural glasses to assess stability questions, supercritical water oxidation of hazardous materials as a means of destruction - Bob Bodnar

Geology

Vitrification and ground water chemistry - Sinha, A. K.

Industrial and Systems Engineering

Selection, qualification, and integration of D&D technologies to accomplish the D&D mission cost-effectively - Wolter J. Fabrycky,

Worker protection (especially chemical and hearing), warning signal design, systems engineering, human factors engineering - John G. Casali

Mechanical Engineering

Chemically reacting flows, pollutant formation in combustion, optical and laser techniques, incineration, light ablation, plasma torch, air sampling, air quality, and effluent monitoring - Uri Vandsburger

Microwave materials processing - J. Thomas

Robotic systems for nuclear steam generator inspection and repair and nuclear reactor inspection, ultrasonic inspection of reactor vessel welds, variable geometry trusses - Paul H. Tidwell, II

Robotics, especially in nuclear service work - Charles Reinholtz

Mining and Materials Engineering

Remediation technologies for the clean-up of sites under the DOE FUSRAP program, materials characterization and physical separations - Jerry Luttrell

Site characterization and design of underground repositories for nuclear waste - Malcolm J. McPherson

Physics

Radiation detectors, scintillation counters, proportional chambers and wire chambers for detecting nuclear particles - David Jenkins

Radiation Safety

Radiation safety, involved in the decommissioning of Virginia Tech's research reactor -
Douglas C. Smiley

Statistics

Environmental statistics (worked in environmental science area at Oak Ridge) - Eric Smith

Veterinary Medicine

Enzymatic decontamination techniques - Nammalwar Sriranganathan & Thomas Toth

Wood Science and Forest Products

Separations, ion exchange, filtration and microbial degradation, biomass fiber sources as
metal scavengers - Wolfgang Glasser

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Virginia Tech's home page - <http://www.vt.edu/>

West Virginia University

Several research projects related to D&D are already underway in Chemistry, Chemical Engineering, Civil and Environmental Engineering, and Mechanical Engineering.

Analysis of the Vortec Cyclone Melting System (VMS) for Remediation of PCB Contaminated Soils Using CFD.

Treatment of Mixed Wastes via Fluidized Bed Steam Reforming.

Use of Centrifugal Membrane Technology with Novel Membranes to Treat Hazardous/Radioactive Wastes.

Development of Instrumental Methods for Characterization and Analysis of Nuclear Wastes and Environmental Contaminants.

Production and Evaluation of Biosorbents and Cleaning Solutions for use in Decontamination and Decommissioning.

For more information contact:

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West Virginia University's home page - <http://www.wvu.edu/>

Appendices

Agenda

D&D Workshop -- Defining Research Needs The Hotel Roanoke and Conference Center August 8 and 9, 1996

THURSDAY - AUGUST 8, 1996

- 7:00 am Registration / Continental Breakfast
- 8:00 Introduction
Paul R. Wieber, Assoc. Dir. for Institutional Development, DOE / METC
- 8:15 Welcome
Leonard K. Peters, Vice Provost for Research and Graduate Studies, Virginia Tech
- 8:25 EM Organization Description / Program Outline
Stephen C. T. Lien, Chief Scientist and Senior Technical Advisor, DOE / Office of Science and Technology
- 8:45 Current D&D Program
Paul Hart, Product Manager, D&D Focus Areas, DOE / METC
- 9:00 Output from 1995 Workshop
Steven J. Bossart, Project Manager, DOE / METC
- 9:30 Results of July 1996 Site Technology Coordination Group Meeting
Paul Hart
- 10:00 Break
- 10:30 Industry Needs Panel
Moderator - Robert C. Bedick, Manager, Environmental Business Sector, DOE / METC
- 11:30 Presentation of TACO Concept
Paul R. Wieber
- 11:45 Working Group Topic Definitions
John R. Duda, Project Manager, DOE / METC

Noon Lunch

1:00 pm Working Group Assignments
 John R. Duda

1:15 Breakout Sessions
 Working Group I
 Working Group II
 Working Group III
 Working Group IV

5:30 End Breakout Sessions

7:00 Dinner
 Clyde W. Frank, Deputy Assistant Secretary, DOE / Office of Science & Technology

FRIDAY - AUGUST 9, 1996

7:30 am Continental Breakfast

8:00 Working Group Report Preparation
 Working Group I
 Working Group II
 Working Group III
 Working Group IV

9:00 Working Group Presentations
 Moderator - Rita A. Bajura, Deputy Director, DOE / METC

10:30 Break

11:00 Discussion of Reports and Meeting
 Moderator - Rita A. Bajura

Noon Closing
 Rita A. Bajura

Meeting Participants

Rock Aker, Project Manager, COMED, Nuclear Strategic Svcs
Rita A. Bajura, Deputy Director, U.S. Dept of Energy/METC
Jim Barrett, Mgr, Technology Development, B&W Nuclear Envir Svcs, Inc
Thomas F. Bechtel, Director, U.S. Dept of Energy/METC
Buddy Beck, Corporate Vice President, Coleman Research Corporation
Robert C. Bedick, Environmental Business Manager, U.S. Dept of Energy/METC
Raymond Berry, Principal Engineer, Yankee Atomic Electric Company
Duane F. Berry, Assoc Prof, Envir Biotechnology, Virginia Tech
Roseanne Black, Waste Policy Institute
Steve Bossart, Project Manager, U.S. Dept of Energy/METC
Marvin Brooks, Waste Policy Institute
Eugene F. Brown, Associate Provost, Virginia Tech
George F. Brown, Jr., Executive Vice President, ICF Kaiser International, Inc.
Larry Buff, Program Manager, Arrey Industries Corporation
Richard Burton, Industrial Liaison, Hemispheric Ctr for Env Tech
Carey R. Butler, Senior Engineer, Waste Policy Institute
James J. Byrne, Manager, D&D, GPU Nuclear, Inc.
Ralph Cady, Senior Hydrologist, U.S. Nuclear Regulatory Comm
Cliff Carpenter, Project Engineer, U.S. Dept of Energy/METC
Stanley Chanesman, RCI Program Manager, U.S. Department of Commerce
Shiao Hung Chiang, Professor, University of Pittsburgh
E.E. 'Bud' Cook, Berry Chair/Professor, Civil & Environmental Engineering
James R. Cross, Mgr, D&D Business Development, BNFL, Inc.
Floyd W. Crouse, Dir, Environmental & Waste Mgt, U.S. Dept of Energy/METC
Jack Davis, Waste Policy Institute
John R. Duda, Project Manager, U.S. Dept of Energy/METC
M.A. Ebadian, Director, Hemispheric Ctr for Env Tech
Roy Eckart, Assoc. Dean of Engineering, University of Cincinnati
Don Eggett, Special Administrator, Commonwealth Edison

Tom Erickson, Senior Research Manager, EERC
Dean Eyman, Waste Policy Institute
Wolt Fabrycky, Senior Research Scientist, Virginia Tech
Clyde W. Frank, Deputy Assistant Secretary, U.S. Department of Energy
Joyce Freiwald, President, F2 Associates Inc.
Karl Frohne, Project Manager, U.S. Dept of Energy/METC
Gene Gardner, Waste Policy Institute
Madhav R. Ghatge, Director, Tech Base Proj Mgmt, U.S. Dept of Energy/METC
B. Gopalakrishnan, Associate Professor, West Virginia University
James E. Gutzwiller, VP, Chemistry & Envir Services, Framatome Technologies, Inc.
William R. Hamel, Associate Professor, Univ of Tennessee - Knoxville
Paul Hart, Product Mgr, D&D Focus Areas, U.S. Dept of Energy/METC
Archer A. Haskins, VP, Business Development, Pajarito Scientific Corp.
Bruce Holmgren, Engineering Manager, Yankee Atomic Electric Company
Nate Hurt, VP/Dir, Oak Ridge Operations, IDM Environmental Corporation
Joseph Jarvis, Vice President, Arrey Industries Corporation
William A. Jester, Professor of Nuclear Engineering, Pennsylvania State University
Harry Johnson, Senior Tech Advisor, ARCTECH, Inc.
Jesse H. Johnson, Govt Liaison Representative, Pall Corporation
R. Martin Jones, Assoc. Professor & Chair, Medical Univ of South Carolina
Dale L. Keairns, Mgr, Chem & Envir Technologies, Westinghouse
William B. Keller, Operations Director, Waste Policy Institute
Werner Kohler, Professor, Virginia Tech
Robert Landolt, Professor of Health Sciences, Purdue University
Peter B. Lederman, Director, Ctr for Envir Engr & Science
Elizabeth Lewis, Quality Assurance Manager, IUOE National HAZMAT Program
Stephen Lien, Chief Scientist, US Department of Energy, FM-50
Akhtar Lodgher, Mgr, Information Technology Prog, Marshall Univ Environmental Ctr
Gary L. Long, Associate Professor of Chemistry, Virginia Tech
Shawn Looney, Research Assistant, Virginia Tech
Gilbert Lovell, Staff Engineer, Lockheed Martin
Marianne Lynch, Environmental Protection Spec, U.S. EPA / FFRRO

Susan Madaris, D&D Program Manager, Hemispheric Ctr for Env Tech
 Stephen Marchetti, Vice President, Parsons Infrastructure
 James Marsh, U.S. Dept of Energy/METC
 Hank McGuire, Vice President, DOE Programs, Foster Wheeler Envir Corp
 William McPhee, President, LTC AMERICAS INC
 Ed Merz, Waste Policy Institute
 L.F. Miller, Professor, Univ of Tennessee - Knoxville
 Neil Naraine, Program Manager, U.S. Dept of Energy/HQ
 Bob Noren, Dir, Nuclear Fuel Fabrication, General Atomics
 Michael S. O'Connell, Program Manager, D&D, Battelle Pantex
 Edward O'Donnell, Geologist, U.S. Nuclear Regulatory Comm
 William R. Ott, Senior Project Manager, U.S. Nuclear Regulatory Comm
 Michael Pastor, Research Assistant, Virginia Tech
 Brian Payea, Director, R & D Management, Molten Metal Technology
 Katie Phillips, Waste Policy Institute
 Daniel J. Quinn, Project Manager, IDM Environmental Corporation
 James B. Radziminski, Associate Dean of Engineering, University of South Carolina
 D. Denise Riggi, Contract Specialist, U.S. Dept of Energy/METC
 Rod Rimando, Decommissioning Program Mgr, DOE-Savannah River Operations
 W. Keith Rylant, Business Development Manager, Tennessee Valley Authority
 Dana J. Santi, Team Leader, Technology App, Rocky Mtn Remediation Svcs
 Matthew P. Schuetze, Program Manager, Nuclear Engr, Nuclear Expertise, Inc.
 Stephen Schutt, Executive Vice President, Nuclear Fuel Services, Inc.
 John W. Shipp, Jr., Manager, TVA Environmental, Tennessee Valley Authority
 Harold Shoemaker, Project Manager, U.S. Dept of Energy/METC
 Larry Stebbins, Acting Mgr, Techology Programs, FERMCO
 John Stevens, Waste Policy Institute
 Jamie Stewart, Waste Policy Institute
 Vince Van Brunt, Professor of Chemical Engineering, University of South Carolina
 Daman S. Walia, President & CEO, ARCTECH, Inc.
 Rod D. Warner, Envir Restoration Branch Chief, US Department of Energy
 Harvey Weisenfeld, Vice President, Energetics, Inc.

W. Mark Weldon, Lockheed Martin Envir Sys&Tech

Richard Edwin Weyers, Professor of Civil Engineering, Virginia Tech

Paul R. Wieber, Assoc. Dir. for Institutional Devl, U.S. Dept of Energy/METC

Paul F. Ziemkiewicz, Dir., Envir Technology Division, WVU-Natl Res Ctr for Coal/Engr

Acronyms

CRADA	Cooperative Research and Development Agreement
EM	Office of Environmental Restoration and Waste Management
D&D	Decontamination and Decommissioning
DOE	U.S. Department of Energy
METC	Morgantown Energy and Technology Center
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
OST	Office of Science and Technology
R&D	Research and Development
VPI	Virginia Polytechnic Institute and State University